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Art. XIV.—*Ecological Studies in Victoria. Part IV.—Basalt Plains Association.*

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The Basalt Plains are very extensive in Victoria, stretching from the vicinity of Melbourne to near the South Australian border. They are generally characterized throughout by an absence of trees and shrubs. Occasionally, either isolated specimens of *Casuarina stricta,* or more rarely in the western parts, of *Acacia melanoxylon* are met with. At times, *Casuarina stricta* occurs singly or in small dense clumps, similar to those formed by *Casuarina Luehmannii,* which is also present at Bacchus Marsh, in the grass lands of the north-west. Both *Eucalyptus rostrata* and *E. ovata* occur at times in open formations, especially where water tends to lie for some time. However, the trees are never tall and may be very much bent with the wind. Both *E. hemiphloia* and *E. melliodora* are found in the eastern parts. With these exceptions the plains are covered with low herbage, but during October and November the inflorescences of the grasses give a much higher vegetation. At this period of the year the grasses are very conspicuous, but so also are other plants, by reason of their flowers. It is characteristic of the Basalt Plains vegetation that the flowers of several families are carried aloft, frequently on long stalks. As soon as the weather becomes hot and dry the flowering period rapidly passes, and, owing to the extra height of the grasses, the plains assume a yellowish colour. Most of the vegetation passes into a resting stage until the following autumn, when the amount of evaporation decreases sufficiently to allow the rainfall thoroughly to moisten the soil. Vegetative activity then recommences, and continues slowly through the winter, but in the spring growth is rapid and there is, in late spring and early summer, a burst of floral activity.

The vegetation of the Basalt Plains may be described as Steppe, in so far as the spring and summer aspects are concerned. It consists largely of grasses which are grey-green in colour, and which do not form a close turf, but occur in tufts (Fig. 3) separated from one another by patches of bare earth which usually, during the summer season, open out into a series of cracks. Associated with the grasses is a large number of herbaceous dicotyledonous herbs, among which members of Compositae are particularly abundant. The burst of vegetative and reproductive activity in the spring, the dormancy during the hot

period of the year, the patches of bare ground between individuals, the absence of trees, and the dominance of the grasses naturally class this type of vegetation as Steppe.

When, however, we turn to descriptions of Steppe by various authors, we find there are characteristics mentioned, not to be found in this Association. The features of Steppe given by Schimper (1903) agree in general with those found in basalt plains, except for the statement that, in the winter, the superficial parts of plants are mostly dried up. On the Basalt Plains, the vegetation is greenest during the winter. Warming (1909) states that there are two periods of rest, in summer, and in winter. On the Basalt Plains there is only one, from mid-summer until the late autumn. Warming states that the summer period of rest is due to drought, which is the case here, while the winter rest is due to cold. That is not the position here for the temperatures are mild enough for vegetative and floral activity (Fig. 5). These statements are further emphasized by the remarks that the summer is exceedingly hot and dry, while the winter is very severe and long with violent snow storms. This latter climatic feature is wholly unknown on the Basalt Plains. However, Warming notes several features which are typical of these plains, such as the perennial tufted grasses, bulbous or tuberous plants, grey-green faded tone, and cracks in the soil. He also states that annuals are a feature of Steppes, but this is not so on the Basalt Plains. Further, Warming notes that where edaphic conditions are favorable, forest occurs. This is to be seen at Broadmeadows, for example, where Grey box, *E. hemiphloia*, occurs.

Lundegardh (1930) considers that the conditions for Steppe are, annual rainfall below 40-50 cms. (16 to 20 inches), dry summers, and soil constitution which retains the rainfall in the upper layers. The rainfall is approximately 25 inches, evenly distributed throughout the year, but the portion which falls in the summer period is lost for plant use due to high evaporation. Lundegardh also refers to the fact that in Steppes the soil is frozen in winter. Much more descriptive language is used by Haviland (1926) with regard to climate. This author states that "fierce extremes of climate are an outstanding feature." To sum up, the points of agreement between these authors and the conditions existing on the Basalt Plains of Victoria are, character of herbage, treelessness, dry hot summer, nature of soil and period of rest, while the chief point of difference is concerned with the winter period. In other lands, there is an intensity of cold and consequently a cessation of vegetative activity.

We may define Steppe, therefore, as xerophytic grass land where the grasses do not form a turf, but exist in clumps distinct from one another, with bare ground between them. Associated with the grasses are a large number of other herbaceous species,

which reach their peak of activity in the spring, and then pass into a resting period. The temperatures are high in summer, and the rainfall in this season insufficient for vegetative activity. With a moderate rainfall, such as occurs in this State, soil is an important factor in determining Steppe. At lower rainfalls soil ceases to have effect, and probably rainfall is the sole determining factor.

Composition.

The composition of the flora of the Basalt Plains Association differs very widely from those of the other two large associations adjacent to it in the metropolitan area, the Heath on the Tertiary Sands and the Sclerophyll Eucalypt Forest on the Silurian sedimentary rocks. All three associations exist under similar climatic conditions. On the Basalt Plains, the two families with most representatives in genera, species, and individuals are Gramineae and Compositae. No other family approaches them in these respects. Each dominates the landscape at its respective flowering period, the grasses following quickly on the Composites. Both of these are amongst the ten largest families in Australia. Of these ten, the other eight families are feebly, if at all, represented on the Basalt Plains. Thus the Myrtaceae, except for occasional species of Eucalyptus, are wholly absent. So also are the Leguminosae except for *Kennedya prostrata,* which is fairly common. *Eutaxia microphylla* is very occasionally found as is *Acacia melanoxylon* in the plains further west. The Proteaceae are wholly absent about Melbourne but further away *Banksia marginata* occasionally occurs. The Epacridaceae are entirely absent. Characteristic Australian families which are not contained in the ten largest families of the Commonwealth, and which are absent from the Basalt Plains, are Dilleniaceae and Tremandaceae. Other characteristically Australian families, although not exclusively so, are feebly represented, such as Goodeniaceae, which is represented by two genera, each with a single species, and Stackhousiaceae, also by a single species.

The uniqueness of this flora lies in the absence or sparseness of characteristic Australian genera and families, Sutton (1916), rather than in the possession of any special features of its own. The rarity or absence of so many dominant Australian genera is not due to any incompatibility between the environment of this association and those families and genera themselves, but to the fact that such plants are, for the most part, either shrubs or trees. Where this incompatibility lies it is not possible at present to say. The comparatively low rainfall, or its almost even distribution throughout the year, cannot be considered to be inhibitory to woody plants, for such growth forms are abundant in a similar rainfall on the Tertiary Sand Plains adjoining. Further, trees and shrubs are the dominant feature of the Mallee, where the rainfall is less than half that on the Basalt Plains. Except in the

extreme limit, rainfall alone does not determine the type of vegetation. Nor can the lack of opportunity for trees to develop be a determining factor. On all sides, the Basalt Plains abut on older geological formations which are abundantly tree clad. Where islands of other geological formations occur in the basalt, these are tree clad, but the basalt is not. Even where the older adjoining tree clad geological formations are much higher in elevation, tree growth does not necessarily occur, although as Sutton (1916) has noted, there may be an encroachment of trees along the margin.

In the open plains, wind may very rightly be considered an adverse factor, owing to the very high evaporation demands, but, even in sheltered areas, trees do not occur on the basalt.

The past history of the area has likewise nothing to do with present day treelessness. It is often suggested that wide, extensive grass lands in the Northern Hemisphere are due to the activity of man. Fire is said to have been his agent in preventing or destroying forest growth, so that there could be ample grass lands for herds or for the chase. In this country there has been neither extensive population, nor large herds of grazing animals. It is one of the great assets of this country that, at the time of white settlement, its native vegetation was wholly related to the physical environment, and was undisturbed by man or animals. That there appears to be no absolute inhibiting factor is shown by the fact that trees can be established artificially by opening up the ground and temporarily destroying the native vegetation. The inhibition of trees and shrubs appears to lie in the inability of their seedlings to establish themselves in competition with the Basalt Plains vegetation. It is in the seedling condition that they are eliminated. The same phenomenon appears to be operating in regard to the invasion by introduced plants. So long as the natural vegetative covering, open though it be, is maintained, entrance to new-comers is denied. Overgrazing, cultivation, or, it may be, extreme drought, gives the opportunity for new-comers to establish themselves. Although trees can be established artificially, and can live for a long time, once they die the plains vegetation will again occupy the area. In a state of nature, vegetation is in harmony with the physical, and generally also, with the biological, environment. Under the existing conditions, vegetation has effectively occupied land surfaces, and the entrance of new-comers is most difficult. So long as the land be effectively occupied, there is no opportunity for the entrance of new-comers.

Below is given a list of plants found on the Basalt Plains. The flowering of each species has been carefully followed each month of the year. The records were first taken in Coburg, where the soil is black, and subsequently, the main area studied has been from Keilor to Melton, but particularly from Albion to

Sydenham. Following is a list of plants commonly found on the Basalt Plains. A census of plants found in all associations associated with the Basalt Plains is given by Sutton (1916). In this paper only the Steppe is considered.

TABLE I.—COMPOSITION OF BASALT PLAINS ASSOCIATION.

V.C. = Very Common, C = Common, F. = Frequent, R. = Rare, V.R. = Very Rare.

Pteridophyta.

POLYPODIACEAE.	*Cheilanthes tenuifolia.* V.C.

Spermaphyta.

Monocotyledonae.

ANGIOSPERMAE.

GRAMINEAE.	*Themeda triandra.* V.C.
	Stipa aristiglumis. F.
	S. setacea. F.
	S. scabra. F.
	Calamagrostis filiformis. C.
	Dichelachne crinita. C.
	Danthonia geniculata. F.
	D. semiannularis. V.C.
	Chloris truncata. F.
	Poa caespitosa. F.
	Agropyrum scabrum. F.
LILIACEAE.	*Anguillaria dioica.* R.
	Bulbine bulbosa. R.
	Thysanotus tuberosus. F.
	T. Patersonii. F.
	Caesia vittata. R.
	Dichopogon strictus. F.
	Arthropodium minus. F.
	Dianella laevis. F.
	D. revoluta. F
ORCHIDACEAE.	*Prasophyllum fuscum.* V.R.
	Diuris alba. R.
	D. pedunculata. R.
	Microtis porrifolia. V.R.

Dicotyledonae.

ARCHICHLAMYDEAE.

POLYGONACEAE.	*Rumex dumosus.* F.
CHENOPODIACEAE.	*Atriplex semibaccatum.* R.
AMARANTACEAE.	*Trichinium spathulatum.* F.
CARYOPHYLLACEAE	*Spergularia rubra.* R.
	Polycarpon tetraphyllum. R.
DROSERACEAE	*Drosera Whittakeri.* R.
CRASSULACEAE.	*Crassula Sieberiana.* C.
LEGUMINOSAE.	*Kennedya prostrata.* F.
GERANIACEAE.	*Geranium pilosum.* F.
	Erodium cygnorum. F.
OXALIDACEAE.	*Oxalis corniculatus.* F.
LINACEAE.	*Linum marginale.* F.
POLYGALACEAE.	*Bredemeyera ericinum.* R.

Stackhousiaceae.	*Stackhousia monogyna.* R.
Guttiferae.	*Hypericum japonicum.*
Thymeleaceae.	*Pimelea curviflora.* F.
	P. humilis. C.
	P. serpyllifolia. F.
Umbelliferae.	*Daucus glochidiatus.* F.
	Eryngium rostratum. C.

Metachlamydeae.

Gentianaceae.	*Sebaea ovata.* C.
	Erythraea spicata. C.
Convolvulaceae.	*Convolvulus erubescens.* C.
Boraginaceae.	*Myosotis australis.* R.
Labiatae.	*Ajuga australis.* R.
Scrophulariaceae.	*Veronica gracilis.* V.R.
Plantaginaceae.	*Plantago varia.* V.C.
Rubiaceae.	*Asperula scoparia.* V.C.
Campanulaceae.	*Wahlenbergia gracilis.* V.C.
Goodeniaceae.	*Velleya paradoxa.* C.
	Goodenia pinnatifida. C.
Compositae.	*Vittadinia triloba.* C.
	Minuria leptophylla. C.
	Brachycome decipiens. C.
	B. calocarpa. V.C.
	B. exilis. R.
	Myriocephalus rhizocephalus. R.
	Calocephalus citreus. V.C.
	Craspedia chrysantha. C.
	C. uniflora. C.
	Rutidosis leptorhynchoides. C.
	Podolepis acuminata. C.
	Leptorhynchus squamatus. V.C.
	Helichrysum apiculatum. V.C.
	Helipterum australe. F.
	Erechthites quadridentata. F.
	Cymbonotus Lawsonianus. F.
	Microseris scapigera. R.

An important point is the high percentage of metachlamydeous and monocotyledonous plants present as compared with the generally more numerous species of Archichlamydeae. This is probably to be explained by the fact that Archichlamydeae represent the older groups of plants, whose members have become established on older geological formations. The Basalt Plains are young geologically, and constitute a type of environment, flat, windswept, and with low rainfall, which was not known in older geological times. It could be peopled therefore by families which were plastic enough to produce forms capable of meeting the new conditions. The habitat was not suited for the development of the erect woody plants, and the herbaceous perennial became dominant.

Characteristics.

The species which constitute an association have characteristics, which collectively give to it its particular physiognomy. In the Cheltenham Flora (1932) it was noted that the ericoid

type of shrub was a notable character. In the Basalt Plains, the herbaceous perennial is an outstanding feature. The life forms alone, however, are not responsible for the physiognomy. In each type of association the spacial relations of the individuals and of the species to one another are also important. As will be seen from Fig. 3 this distribution is very varied.

On the Basalt Plains, owing to the fact that the vegetation is herbaceous, there is a high number of species per unit of area. In Fig. I., is shown a graph of the average number of species per unit of area, which, in this case, was a square yard. The general form of the graph, with a sharp rise at the commencement of the curve, is typical of such species—area curves. It will be noted that at the end of the curve the species increment per square is only .2. The further increase in the number of species with additional area will be exceedingly slow.

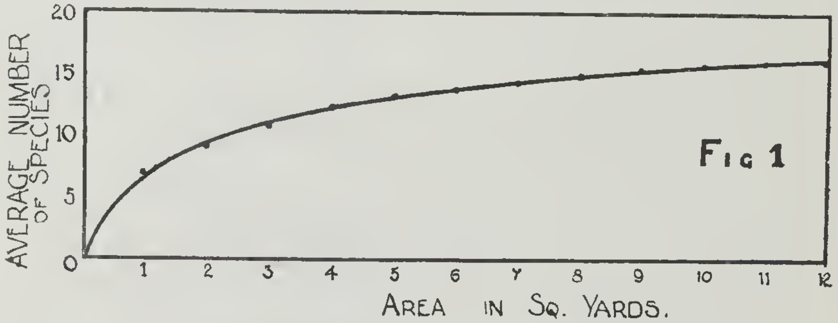

Fig. 1.—Relation of Average Number of Species to Area.

Although the average number of species is only 16.3 for twelve square yards, the actual number of species occurring in the plots was 45. This number represents 60 per cent. of the total number of species given in Table I. Such an apparently low value is quite natural, however, and is due to a number of causes. In a climate where the period of growth is extended over several months, there is a succession of vegetative and floral activity, and therefore, whenever an investigation be made, some of the plants will be absent. Thus *Pimelea serpyllifolia* flowers in July, while *Erythraea spicata* not until December. This latter plant is just commencing its vegetative activity at about the period when the majority reach maximum floral activity. Secondly, a large number of plants, which are definitely characteristic of this association, are only very sparsely present. *Goodenia pinnatifida* might be regarded as such, although it occurred in only 16 per cent. of the plots. Thirdly, there are those which are only spasmodically present, and whose presence does not affect the general

physiognomy or aspect of the association. This feature is best shown by means of a frequency diagram (Fig. 2).

In the Basalt Plains the greatest number of species falls in the lowest frequency class. This is quite frequently the case but not always so. In Fig. 2, there is only one maximum, but in many associations there may be another in the highest frequency class.

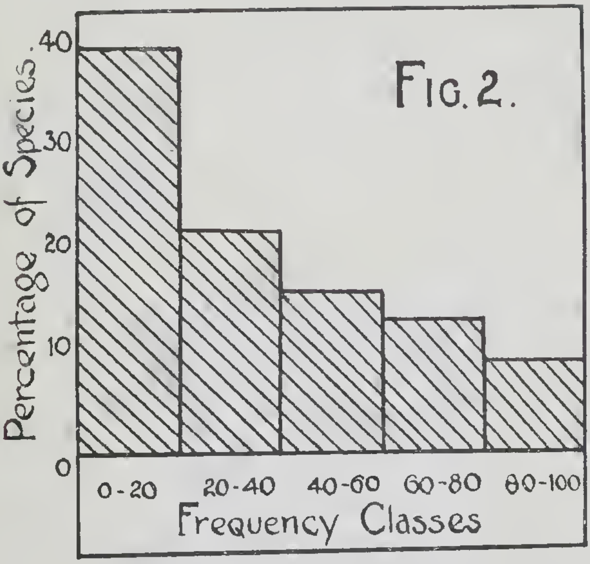

Fig. 2.—Frequency Diagram of Basalt Plains Association

The frequency diagram, however, is not an altogether satisfactory measure of distribution of species, for it will vary with the size of the unit area used in the investigation. The larger the unit area, the less will be the number of species in the lowest frequency class. In such a diagram as Fig. 2, only the number of species is considered, and therefore it conveys no information in regard to the number of individuals present. This is not easy to present either diagrammatically or quantitatively, for there are constant variations in the local composition. The sociability of the species themselves affects this phenömenon. Some of the species as *Themeda triandra, Danthonia semiannularis* and *Helichrysum apiculatum*, grow in clumps, particularly the latter, while others, as *Goodenia pinnatifida*, grow as isolated plants. *Plantago varia* very often forms little colonies. The nature of the distribution as well as the sociability of the various species, is shown in Fig. 3. The amount of bare ground between the plants is also seen.

Another characteristic of an association is the low number of species per genus. It is comparatively rare to find a genus with a large number of species in an association.

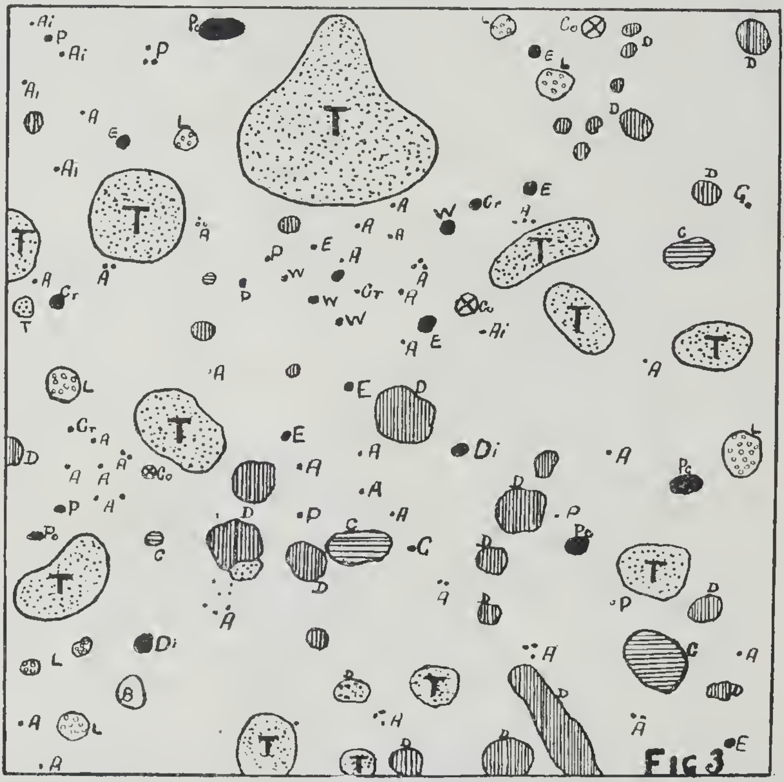

Fig. 3.—Distribution of Vegetation in a Single Quadrat.

A. *Asperula scoparia.*
Ai. *Aira caryophyllea.*
B. *Brachycome calocarpa.*
C. *Calocephalus citreus.*
Co. *Convolvulus erubescens.*
Cr. *Crassula Sieberiana.*
D. *Danthonia semiannularis.*
Dg. *D. geniculata.*
Di. *Dichelachne crinita.*
E. *Eryngium rostratum.*
G. *Goodenia pinnatifida.*
L. *Leptorhynchus squamatus.*
P. *Plantago varia.*
Pc. *Poa caespitosa.*
Po. *Podolepis acuminata.*
T. *Themeda triandra.*
W. *Wahlenbergia gracilis.*

As will be seen from Table I., three is the largest number of species belonging to a genus in the Basalt Plains Association. A family, however, may frequently be represented by a large number of genera. In this association, there are several such examples; Gramineae is represented by eight genera, Liliaceae by seven, and Compositae by fourteen. In Table II. is given a list of associations with the average number of species per genus.

TABLE II.—NUMBER OF SPECIES PER GENUS FOR SEVERAL ASSOCIATIONS.

Association.	Country.	Author.	Number of—		Number of Species per Genus.
			Genera.	Species.	
Cheltenham Flora	Australia . .	Patton . .	50	56	1·1
Fern Gully . .	,, . .	,, . .	43	57	1·3
Sand Dunes . .	,, . .	,, . .	21	21	1·0
Basalt Plains . .	,, . .	,, . .	61	72	1·2
Mulga Scrub . .	,, . .	Collins . .	44	93	2·1
Fjaeldmark . .	Spitzbergen	Michelmore . .	26	49	1·9
Heath . .	Norway . .	Leach and Polunin	26	33	1·3
Poplar . .	Canada . .	Moss	117	180	1·5
Hemlock Beech	U.S.A. . .	Lutz	78	101	1·3
Heath . .	England . .	Moore	25	26	1·0

Habitat.

(*a*) *Climate—Rainfall.*—The climatic factors are the same generally as those existing in the heath lands (Cheltenham Flora 1932) immediately to the south of Melbourne. These two plant communities, Heath and Steppe, are therefore in close proximity to one another, and, being at almost the same elevation, a few feet above sea level, and both occurring on plains, they must naturally be subject to the same general climatic influences. To the south of the Basalt Plains, as they stretch westward, there lie other occurrences of the heath flora. This latter occurs extensively, for instance, along the coast from Port Campbell to Peterborough. The heath in this latter case does not abut directly on to the Basalt Plains, for a belt of messmate forest intervenes. It is probable that wind has a greater effect on the Basalt Plain than on the heath land, owing to the absence of any tree or shrub vegetation, but, against this is the fact that the vegetation is so close to the surface that the effect of the wind is greatly lessened, owing to the loss of velocity due to the surface of the earth. In any case, differences of climate cannot be great, for these two associations, Heath and Steppe, come into close contiguity at a number of places. Brockmann-Jerosch and Rübel (1912), in their "Ideal Continent," considered that heath is a consequence of oceanic climate, it being never far from the sea. This is the

case both here and in the Northern Hemisphere. Steppe, however, they consider to be a result of continental climate. Here, however, Steppe also occurs under the influence of an oceanic climate. Climate itself is a composite factor, and its effect is greatly modified by the equally important composite factor—soil. It is the influence of soil and soil alone that is responsible for the two totally different types of vegetation being produced in such close proximity, and the soils of each association owe their differences entirely to the parent rock from which they have been produced.

Climate is made up of a number of individual units, and each of these contributes its quota to the development of vegetation. The effect of climate is best seen in a latitudinal direction. Locally, however, there may be uniformity of climatic conditions, and yet totally different types of vegetation occur adjacent to one another, which is strikingly shown in such a small State as Victoria.

Climate has an influence only in a very general way, but geological factors are almost solely responsible for the very great diversity in vegetation that exists locally. Local climate itself is frequently the outcome of the modification of regional climate due to geological conditions.

On the area studied the rainfall varies from slightly under 20 inches to over 25 inches. This rainfall is almost evenly distributed throughout the year as shown in Fig. 4. The lowest amount received per month is 1.75 inches in February and the highest 2.62 inches in October. Throughout the winter period this usually meets the needs of the plants, but is insufficient for the summer period. Both soil and contour are, however, factors in regard to the ultimate availability of the rainfall for plant use. On the Tertiary Plains the water, owing to the sandy nature of the soil, readily enters and passes downwards, but on the Basalt Plains, rainfall does not readily enter, on account of the high clay content, and therefore a far greater proportion is lost in evaporation. Owing also to the high water holding capacity of the soil, the amount of rain that falls does not penetrate very deeply. For this reason it is difficult for the lower depths to receive adequate supplies of water. However, rain does enter deeply in the autumn period, owing to the fact that the soil is then well opened up, with numerous cracks and water gains ready entrance. Observation and experiments show that such soil will contract in drying approximately 13 per cent. of its area. If sufficient rain falls, the cracks fill up again.

As the climate is the same for both the Basalt Plains and the Tertiary Plains it is not surprising that the graphs of their flowering periods should be similar. The maximum flowering (Fig. 4) occurs in October, which is also the case in the heath association (Patton, 1932).

Basalt Plains Association.

On the basalt, just as on the Tertiary Plains, there are species which flower in the unfavourable periods of the year. Thus *Pimelea serpyllifolia* flowers in the coldest period when there is but little floral activity but abundant vegetative activity, while *Calocephalus citreus* and *Erythraea spicata* have their maximum periods in January, when both vegetative and floral activity of the majority of the plants, particularly grasses, either has become or is becoming dormant. During January temperatures of over 100 deg. F. may be experienced, and the high temperatures combined with low humidity, strong, dry winds, and low rainfall, makes conditions for plant life very hard indeed. The water relations of such plants as flower in summer present a very interesting problem.

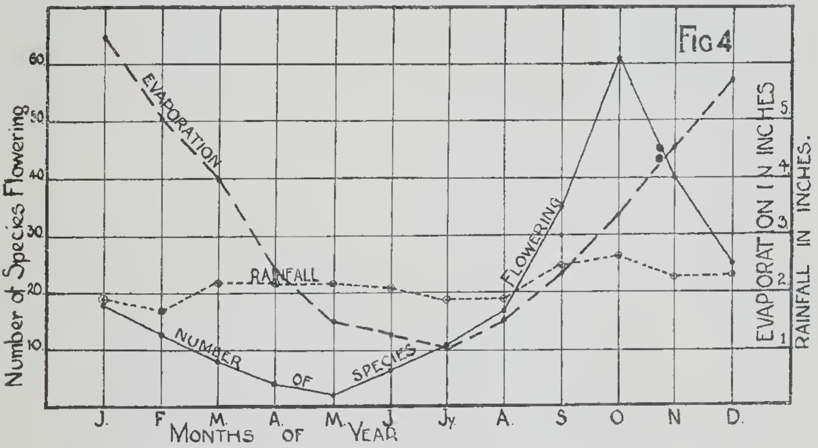

Fig. 4.—Monthly Rainfall, Evaporation, and Number of Plants Flowering.

In Fig. 4 is also shown the amount of evaporation from a free water surface for the metropolitan area. The data for both evaporation and rainfall are taken from the Central Weather Bureau Station, which lies between the two associations, Heath and Steppe. It is again significant that the maximum flowering period lies just about the period where evaporation from a free water surface commences greatly to exceed the rainfall. The effect of the rain during the summer months is lost on account of the high evaporating power of the air. It is possible that the amount lost by evaporation on the plains is slightly higher, due to bareness in part of the soil but the difference would not be great.

Temperature.—Melbourne experiences an oceanic climate. The average temperature for the coldest month is 48.7 deg. F., which is well above freezing point (Fig. 5). Frosts are frequent in the months, May to August, but they are not very severe. The

temperatures in the metropolitan area and its environs are sufficiently low to make impossible the cultivation out of doors of Dahlias, Zinnias, Tomatoes, and French Beans, but it is sufficiently high to enable such plants as White Turnips, Cabbages, Garden Peas, Broad Beans, Iceland Poppies, Violas, and Sweet Peas, to grow quite actively. For many plants there is no cessation of plant activity during the winter. White Turnips sown in April are ready for digging in September. The whole of the stored food material therefore has been produced during the coldest period of the year. In Fig. 5 are given, in addition to the graph of monthly temperatures, also the time intervals between sowing and flowering of garden peas, variety Greenfeast, grown in the metropolitan area for various periods of the year. It will be seen that the seeds sown in autumn take the longest time to reach the flowering stage. This is due to the fact that they are growing while temperatures are falling. They flower, however, in July, the coldest month of the year. From left to right of the graph there is a progressive shortening of the growth period. Winter temperatures are, therefore, high enough

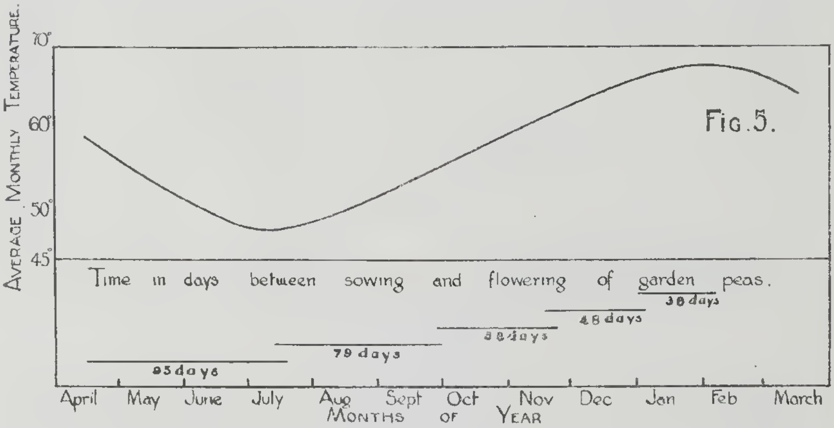

Fig. 5.—Relation between Temperature and Length of Time, in Days, from Sowing to Flowering of Garden Peas.

to permit of a considerable amount of vegetative activity for certain species. The climate of Steppe therefore cannot be considered necessarily to be one of extremes as stated by writers of the Northern Hemisphere. Although there is a similarity between the vegetative activity of some garden plants and the native vegetation, there is a striking contrast between the behaviour of introduced Northern Hemisphere plants such as the common fruits—Pear, Plum, &c.—and the native vegetation. As the temperatures fall in the autumn, so the leaves of cool temperate plants of the Northern Hemisphere begin to fall until by

mid-winter the trees are bare. However, about the time the leaves begin to fall the temperatures in this climate have sufficiently decreased so that evaporation is much lessened and the rain is retained in the soil and is available for plant growth. At this period of the year, that is autumn, the native vegetation awakes from its summer rest. There is, therefore, the paradoxical state of affairs that plants from a cooler climate pass into a winter rest, while the plants of the warmer climate commence their vegetative activity. There are other anomalies in regard to introduced deciduous plants. Peaches go into winter rest before Apples and Pears, which might suggest that they require a warmer climate. However, they rejuvenate earlier. By the end of July, which is the coldest month, peach buds are well advanced towards bursting. Winter temperatures therefore are not low enough to prevent vegetative activity, nor are they too low for the floral activity of many introduced plants such as Jonquils (*Narcissus Jonquilla*), Iceland Poppy (*Papaver nudicaule*), and Hyacinths (*Hyacinthus orientalis*). For the native vegetation, however, it is generally a period of vegetative activity only, and not of floral activity. This is also the case with other native associations.

(*b*) *Soil.*—The Basalt Plains are geologically young, being of Pliocene age, and have not yet been generally greatly dissected. They are either flat or gently undulating, except where the contour is broken at intervals by volcanic cones. The rock is a fine-grained, blue-grey basalt which is not very hard, and which readily weathers into a reddish-brown soil. Although this colour predominates, black soil also occurs, particularly in the lower parts. It would appear that the difference in colour is largely one of contour, owing to the removal of humus from the slightly higher parts, and its deposition in the lower. Contour can have a very marked effect on the development of soil from the same petrographic material. One may observe bracken fern, *Pteridium aquilinum*, growing on the tops of hills formed of shales but lower down on the slopes it is completely absent. The clay has been sufficiently leached out from the higher parts to permit of a soil friable enough for bracken to grow in. The basalt soil is a clay loam which has a water holding capacity of 45 per cent. Seeds will germinate in as low a percentage as 10, but the speed of germination is greatly retarded. With moisture contents above 16 per cent. the speed is not affected. At this latter moisture content the soil is still crumbly but at 19 per cent. it is definitely sticky.

In the areas investigated, the soil is very shallow, and in many parts the bed rock outcrops on the surface. Large areas were formerly strewn with boulders, but these latter now form the stone fences so commonly seen on the plains. This shallowness of the soil greatly restricts root development, and has been

suggested as one of the causes of treelessness. Although the soil is shallow, the profile is very pronounced (Fig. 6). There is a very striking contrast between the A and B horizons and the line of separation is sharp (Plate XIII., B). Horizon A may consist of three sub-horizons, which are best seen when the soil is very dry. A_1 consists of a few inches, 4—6, of darker, finer material, through which the roots readily ramify. A large amount of the clay has been leached out of this portion, and the darker colour is due to the decomposing plant remains. Owing to the lesser clay content, it does not shrink as much as the soil from lower depths. A_2 can be recognized in some profiles as having, when thoroughly dry, a decidedly yellowish tinge. The colour increases in intensity with depth. In this sub-horizon the roots may be freely developed but may be almost absent. The soil

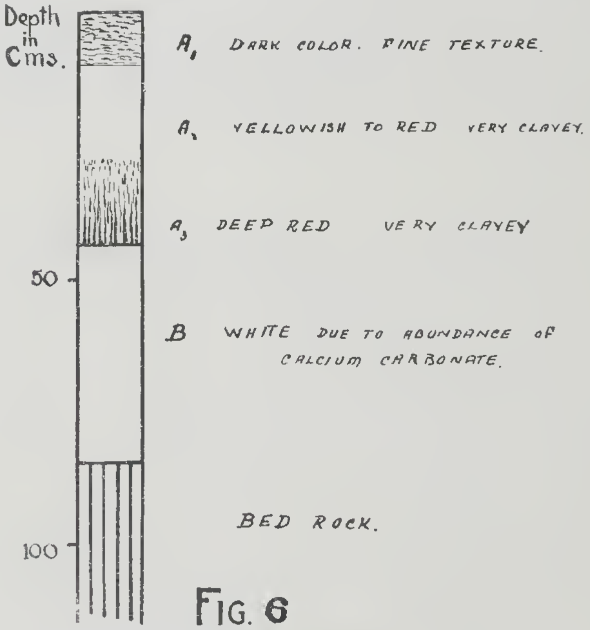

FIG. 6.—Profile of Soil, Basalt Plains

itself has a high clay content and in consequence is subject to a great amount of shrinking. This can be seen where a profile has been exposed during the hot weather.

The sub-horizon A_3 is usually only a few inches in depth and is reddish in colour. This also has a high clay content and is at times permeated by roots.

The horizon B is heavily charged with calcium carbonate and may be in consequence (Plate XIII., B) almost white. This horizon very abruptly succeeds A_3. It rests directly upon undecomposed rock and also passes down to a considerable depth

in the joints of the basalt mass. This horizon is not usually penetrated by roots, although it appears to be generally moist.

Under modern soil classification, this soil is classed as red-brown earth, and according to theory, is produced in a climate where the rainfall is insufficient to leach out the iron from the A horizon but sufficient to leach out the calcium carbonate. The soil of the heathlands (Patton, 1932) shows a more pronounced profile with a very definite carbonaceous sub-horizon, and without any deposition of calcium carbonate. The great difference that exists between the sandy soil of the heath lands and the heavy clay of the Basalt Plains must be looked for solely in the original rocks from which the soils have been derived. Both these associations are under the same climatic conditions, are of the same general elevation and same contour, but the bed rock is entirely different. Both are geologically young, but in point of time are old, and, therefore, there has been abundant time for the climatic conditions to produce a similar soil on both areas, if climate be the final determiner of soil type. Weather is the primary cause of soil formation, but is not a determiner of type. The constitution of the parent rock itself at once becomes a determiner of the process of weathering, and therefore of soil type. Basalt is a finely crystalline, igneous rock, composed of interlocking crystals of ferro-magnesian minerals and lime felspars. Hence, movement of water through such a mass, when weathering, is almost impossible. The weathering can proceed but slowly, from without inwards. In basalt there is no free silica to resist weathering, and hence form a skeleton of the soil through which water can move. The ferruginous sandstone on the other hand does not have its constituent parts interlocked, but is merely a mass of water-worn grains of silica with the interstices between them filled with the cementing material, clay or oxide of iron. Such a coarse material offers a ready channel for movement of water to remove both the clay and the oxide. Hence a sandy soil results. The parent rock is seriously lacking in plant nutrients.

When the basalt weathers there are no coarse grains to provide a channel for moving water. The fineness of the crystals themselves predetermines a fine-textured soil. It is this fineness of crystalline structure that determines in a great measure the manner of the weathering, since water cannot percolate through, and carry away the products of weathering. The rock breaks down into a heavy clay soil, generally reddish in colour. Physically and chemically therefore the two soils are directly the outcome of the nature of the parent rock.

Discussion.

The low number of species per genus has been found to be the case with other associations already discussed in this series. Both the Basalt Plains and the Cheltenham Flora are very rich in number of species while the other two, Sand Dunes and Fern

Gully, are poor. The poverty of the Sand Dunes is understandable since this is a pioneer colonization, but the Fern Gully has every condition favorable. The poverty of species in this latter association is also remarkable since there is a wide range of life forms. However, this association is representative of a very ancient type of vegetation which is on the decline in temperate lands. The other three are more modern and opportunity has been given for the inherent tendency of plants to vary. If we consider the floral composition of the four already studied it may be noted that, alongside the fact that there is a low number of species per genus, as given in Table II., there is also the fact that comparatively few genera are represented by the same species in more than one association. There are a few species, however, that have a very wide ecological range. In both the Heath and the Steppe floras, we find *Pimelea humilis, Kennedya prostrata, Geranium pilosum, Oxalis corniculatus, Anguillaria dioica, Dianella revoluta, Themeda triandra, Leptorhynchus squamatus* and *Wahlenbergia gracilis.* None of these, however, is restricted to the two habitats mentioned but extends over a much wider range of ecological conditions. In alpine vegetation we find, for example, *Pimelea humilis* and *Wahlenbergia gracilis.* Plants that can exist in two widely differing habitats must be very plastic as regards their response to external conditions. Such plants constitute what we have chosen to designate "Ecological Wides." Braun Blanquet (1928) calls these "Ubiquisten." These form an exception to the general rule for distribution, for it is generally found that a species has a limited ecological range, and the limits are shown by the sparsity of occurrence or the modification of the growth of the plant. Thus *Acacia melanoxylon* is sparsely found on the basalt, but it is never a large tree. From the associations so far considered, it can be seen then that the low number of species per genus is a distinct feature of an association. It arises from the fact that plant associations differ primarily from one another owing to the fundamental differences in their habitats. This difference in environment calls forth a difference in response from the numbers of genera concerned. In a long continued environment in which little or no change has been effected, the variation of plants is limited to structural alterations which do not in any way affect the response of the plant to the environment. Such changes produce families, genera, and to a less extent, species. Changes which occur in families to produce genera are changes which do not affect the physiology of the plant. Thus, if we consider *Helichrysum* and *Helipterum*, the differences lie in the plumosity of the pappus hairs. Since these structures are produced at the end of the life cycle of the plant, neither its physiology nor its response to environment can be affected.

Or again let us consider *Lagenophora* and *Brachycome.* The difference between these genera rest solely on the apical portion

of the achene. And again, the difference between *Minuria* and *Vittadinia* lies in the fact that in the former some of the pappus members are developed as bristles. Such generic differences manifest themselves late in the seasonal activity of the individual, and therefore cannot in any way assist the plant in responding to the particular environment. When we consider the several genera *Epacris, Leucopogon,* and *Monotoca,* we find that they are separated on characters which can in no way affect their response to the environment in which they occur. If we consider any particular genus as *Olearia,* which has species in more than one association, we find that the particular generic characters play no part in the economy of the plant and are doubtful indeed of any value whatsoever. Where genera are represented by different species in adjoining associations, it may fairly be assumed that the same agencies are at work in regard to fertilization of such species.

This subject may be pursued indefinitely. Generic characters represent the inherent variability of the plant which is manifested however, only in a limited way and under restriction. So long as the environment remains stationary there can be no production, or at least no survival, of forms whose response is not in harmony with that environment. In a constant environment, plants can only express their capacity to vary in variations that are quite unaffected by the environment, or, it may be, whose variations confer no disability on them to survive. If the plant be already in harmony with the environment, an assumption true for the majority of plants, then the plant cannot vary to make itself more efficient. It can, however, vary without there being any difference as regards response to the environment. We may regard generic variations as being static or passive.

The accumulation of such variations would in time produce families. It is conceivable that variation in this manner could be infinitesimal, and that a variation once started would gather force and be cumulative. Since, however, such variations, be they small or great, are without effect on the plant response to the environment, there can be no survival of the fittest or struggle for existence between such forms. Species can and must arise thus, for we do find several species of a genus in an association but these do not differ in their physiological response.

Another fact which emerges from the study of differing associations in a botanical province is that, generally, while the same species are not found widespread, the same genus, or at least the family is. Thus *Pimelea* has *P. humilis* and *P. phylicoides* on the Tertiary Sands, *P. serpyllifolia, P. humilis,* and *P. curviflora* on the Basalt Plains, and *P. axiflora* as a marginal plant in the Fern Gullies.

If now we consider a genus that is represented by species in more than one association, we find that there is an appreciable difference between such species. *Leptospermum* has two

shrubby, thin-stemmed, small-leaved species on the Tertiary Sands, and a small tree with much larger leaves on the dunes. The two shrubby forms, although quite distinct, each represent a similar type of response to the environment, while the thick-leaved *L. laevigatum* of the coast is quite another type altogether.

Olearia of the Fern Gully is a large-leaved form, but *Olearia axillaris* of the coast and *O. ramulosa* of the heath land are quite distinct.

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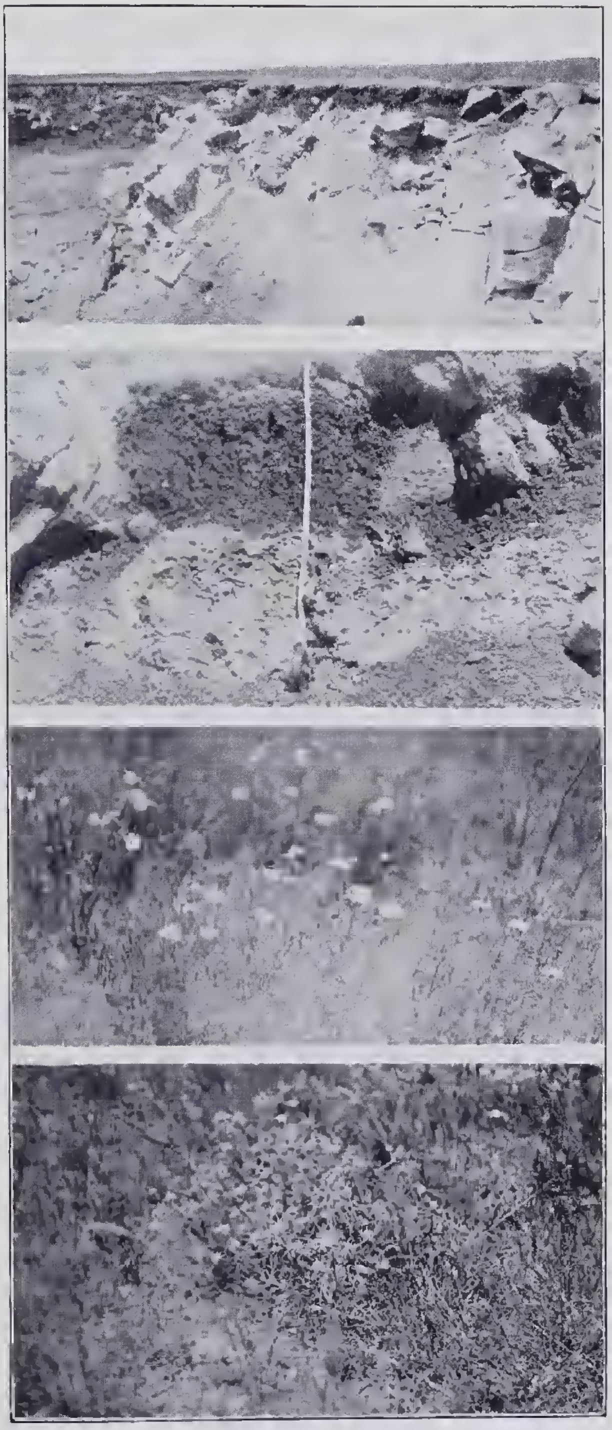
Explanation of Plate.

A. Section of the Basalt Plains showing the very shallow layer of soil.

B. Section of soil, showing dark Horizon A, and light-coloured Horizon B.

C. Typical plant of Basalt Plains, *Brachycome calocarpa.*

D. Another typical plant, *Eryngium rostratum.*



A

B

C

D

Basalt Plains Association.